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Analysis of Students' Errors in Solving the Circle Equation of Class XI Multimedia Students at SMKN 3 Pekanbaru

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ABSTRACT

The inability of students to solve problems will result in errors in solving them. This study aims to describe students' errors in the circle equation material and the factors that cause errors in class XI SMKN 3 Pekanbaru and solve math problems related to circle equation material. This research is descriptive research. The subjects in this study were 36 students of class XI SMKN 3 Pekanbaru. The data collection technique was carried out by means of a learning outcome test which consisted of instruments describing the circle equation. As for the percentage of errors made by students, namely students who made fact errors as much as 29% due to the lack of accuracy of the students in writing the symbols of the circle equation, the students made 23% misconceptions because the students did not understand the questions well so that students are random in determining the formula used to solve the problem, students made a principle error of 16% because the students were careless in determining the formula to solve the questions, students make operating errors as much as 32% because students are not careful in doing algebraic operations and are in a hurry to work on the problem.

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INTRODUCTION

Education is very important for the progress of a country, where education is one of the main factors for an intellectual change for humans and for the intellectual life of the nation. Education is a conscious and planned effort to create an atmosphere of learning and the learning process so that students actively develop their potential to have the power of intelligence, self-control, and skills. Mathematics is one of the earliest disciplines known to mankind, mathematics is also known as the queen or mother of science or main (main) science because mathematics is the source of other sciences, such as physics and chemistry. Mathematics is also a way or method of thinking and reasoning, the language of symbols that can be understood. Therefore, the importance of studying and understanding mathematics is because mathematics has many benefits for human life.

Mathematics is one of the subjects that students take in both formal and non-formal education. Mathematics is an important subject both from a theoretical and applicable perspective in everyday life. Mathematics is the language of symbolic practical functions to express quantitative and spatial relationships while functions theoretical is to facilitate thinking. In particular, mathematics education has a very important role because mathematics is the most important part of the field of science that is used in various fields of life at large. Mathematics as basic science is a means of thinking to develop reasoning power, logical, systematic, and critical thinking. Therefore, mathematics is very important for students to learn from elementary school to college level [1]. Mathematics is a science that examines abstract structures with logical reasoning in statements equipped with evidence and through

necessary research activities, intuition and discovery as problem-solving activities and communication tools, knowledge of numbers and calculations, and the relationship between these things [2].

Mathematics learning itself has various characteristics, one of which is having an abstract study. This abstract nature is the cause of students having difficulties in mathematics, thus allowing students to make mistakes in solving problems. Learning is a process that is carried out deliberately to develop individual abilities optimally. The development of student abilities is a process of change, the changes that occur are in the form of behavior that is caused or changed from the experience. The change is a new ability, both actual and potential abilities. The mistakes made by students need to be analyzed to find a clearer and more detailed picture of the form and causes of students' errors in solving problems. The mistakes made by students can be used as consideration for teacher teaching in an effort to improve learning and teaching activities in the hope that it can improve student learning outcomes. Detailed error analysis is needed so that student errors and their causal factors can be known through the answers given by students from the test [3].

One of the branches of mathematics is geometry. From a psychological point of view, geometry is an abstraction of visual and spatial experiences, such as planes, patterns, measurement, and mapping. Geometry not only develops students' cognitive abilities but also helps students in memory formation, namely concrete objects to be abstract. Based on this opinion, geometry is an important material in learning mathematics. Learning geometry can increase students' interest in mathematics, improve problem solving skills, reasoning, and ease in skills in various mathematical topics and other sciences [4].

Geometry is an introduction to the shape of the area, volume, and area. Building the concept of geometry starts with identifying shapes, investigating buildings, and separating ordinary images, such as rectangles, circles, and triangles. Circles are part of geometry as a basis for studying other shapes such as tubes and cones. However, the circle equation is still a scourge for students, therefore it is necessary to have a learning evaluation that is able to detect student difficulties [5].

The equation of the circle is one part of the scope of geometry, where this material is taught to class XI students. This material is an important material in mathematics that can be applied in everyday life. Students are taught to be able to determine the equation of a circle. Although determining the circle equation can be shown in the learning process, learning it still has an abstract study, so many students have difficulty translating circle equation problems, and the number of formulas that students have to memorize causes students not to be optimal in solving problems related to equations circle [6]. The inability of students to solve problems will result in errors in solving them. If one of the solving steps has an error, it will lead to the next step and result in low learning outcomes obtained by students in solving math problems that need the attention of the teacher, so that the teacher knows the mistakes made by students and the factors that cause students to be wrong in solving math problems. Therefore, it is necessary to have a learning evaluation that is able to detect student difficulties in learning the subject matter of circle equations and the factors causing them to be further identified to help overcome these problems [7].

According to research that has been conducted under the research title "Analysis of Middle School Students' Errors in Solving Problems on Circle Equation Material". The results of the research obtained were students' errors in solving mathematical problems related to the circle equation material as follows: the mistakes most students made when solving problems on circle equation material were errors in understanding the concept with a percentage of 27.75%, other errors were errors in applying the principle with a percentage of 5.55%, errors in doing algorithms with a percentage of 5.55%. Factors that cause students to make mistakes when working on circle equation problems include lack

of understanding of the concept of circle equation material, not mastering prerequisite material, not being careful in working on questions, not being careful when reading questions, and not understanding in understanding the meaning of the questions [8]. Meanwhile, according to research that has been conducted under the research title "Analysis of Student Errors at the Multistructural Level Based on the Solo Plus Taxonomy in Solving Problems with Circle Equation". The results showed that the errors made by students included errors in understanding the problem so that they did not make conclusions, errors in choosing problem-solving procedures to solve problems, errors in writing formulas to solve problems, and unable to solve problems because they did not memorize the formulas that were part of the problem. problem solving [9].

Students' errors are deviations made in completing a predetermined job. So, the errors are a deviation from something that is true [10]. Then the error is a deviation from what is true or a deviation from what has been determined. In line with the opinion above, defining error is a form of deviation from things that are considered true or previously established procedures [11].

The factors of errors made by students in solving questions can be seen from the mistakes made by students which can be classified into several forms of errors, including [12]] (1) errors in performing operations, namely in using algorithms (job procedures), errors in performing count operations; (2) known errors, what is asked of a question; (3) Opinions that sort, classify and present data; (4) placing in the placement of symbols, tables, and graphics that contain some information; (5) perform mathematical manipulation of the properties in solving problems; (6) wrong 1 in terms of. For example, mistakes in mistakes or not including the problems they have worked on.

Common types of mistakes that students make in solving math problems are [13]: (1) Concept Mistakes Concept errors are misunderstandings of abstract ideas. A concept in mathematics is an abstract idea that results in a person being able to classify objects or events and determine whether the object or event is an example or not an example of that idea. (2) Errors in using data are related to errors in using data, such as not using data that should be used, incorrectly substituting data for variables or adding unnecessary data to answer a problem. (3) Language interpretation errors are errors in converting information into mathematical expressions or errors in giving meaning to a mathematical expression. Mathematical language is the language of symbols so that understanding these symbols is the main prerequisite for understanding mathematics. Mathematical problems are usually presented in the form of diagrams, tables, story problems, and so on. All of these have meaning and will become clear if they can be interpreted correctly. (4) Technical errors to incorrect selection of extrapolation techniques. The student cannot identify the exact operation or series of operations. This problem can occur when students choose the wrong path which leads to a dead-end which can be in the form of students' ignorance of choosing the right procedure to complete existing operations. Errors in calculations are considered technical errors. (5) Mistakes in drawing conclusions Errors in drawing conclusions made by students can be in the form of making inferences without the correct supporting reasons or making inferences that are inconsistent with logical reasoning.

In this study, the type of student error used is the type of error according to the Big Indonesian Dictionary, the error is a matter of error, error, omission so that if the error is associated with the basic object of mathematics is; (1) False facts, (2) Misconceptions, (3) Mistakes in principle, (4) Material Operation Error.

Based on this explanation, the researcher conducted research to find out students 'mistakes in solving math problems on the subject of circle equations as contained in the research title "Analysis of Students' Errors in Solving Problems of Circle Equation Materials Based on Class XI Multimedia Students of SMK Negeri 3 Pekanbaru."

METHODS

This type of research is a descriptive type of research. Descriptive research is a statistic that is used to analyze data by describing or describing the collected data as it is without intending to make generalized or generalized conclusions [14]. The research was conducted at SMK Negeri 3 Pekanbaru. The subjects in the study were students of class XI Multimedia at SMKN 3 Pekanbaru in the 2019/2020 academic year, totaling 36 students. Taking the subject in the study using cluster random sampling (area sampling). To obtain research data, the data collection techniques used by researchers were as follows: The data collection technique in this study was to use measurement techniques by collecting the results of students' answers to these questions in the circle equation material. The description questions given to students aim to find out the types of mistakes made by students. After the students' answers are checked, then the wrong answers are selected and grouped according to the type of error. Examples of student answers with errors are presented in the form of pictures and describe where the mistakes were made by the students. The data analysis technique was carried out by correcting the results of student work. Then test the validity, reliability, differentiation, and difficulty level of the questions using the Microsoft Excel application, then proceed with analyzing the types of student errors and determining the percentage of errors in facts, concepts, operations, and principles.

Interview techniques are used to determine student error factors in solving circle equation problems. The instrument used in this research is the main instrument including the researcher himself, then after the research focus becomes clear, other instruments are developed including test instruments and interview instruments. Data validity is carried out by triangulation of data collection techniques, which means that the researcher compares the test result data, the interview data. The data analysis technique of this research was carried out with 3 activity lines, namely: (1) Data reduction, namely the stage of correcting the answers to the students' test results that have been collected to find types of errors and recording the results of interviews; (2) Data presentation is the process of collecting information or data the results of research that have been compiled and organized that allow for drawing conclusions; (3) Verification (drawing conclusions) is the process of drawing conclusions about student errors so that problems and research objectives can be achieved.

RESULTS AND DISCUSSION

The data analysis technique was carried out by correcting the student's work. Then test the validity, reliability, differentiation, and difficulty level of the questions using the Microsoft Excel application. The test results are as follows:

1. Validity test

The validity test was conducted to determine the validity level of a post test instrument. Validity is a measure that shows the validity of an instrument. A post test instrument can be said to be valid if it is able to measure what is desired and if it can reveal data from the variables being studied appropriately. The validity of the items was done by correlating the score of each item with the total score obtained by the students. The correlation formula that can be used to calculate the validity is the product moment correlation formula for the rough numbers proposed by Pearson, namely:

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{[N\sum X^2 - (\sum X)\dot{2}][N\sum Y^2 - (\sum Y)\dot{2}]}}$$

Information: r_{xy} = coefficient of validity
$\sum X$ = Total item score
$\sum Y$ = Total score of all items
N = Number of respondents

After that, we perform calculations with the t-test formula to obtain the t-calculated value, namely:

$t_h = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$.

Information: t_h = value of t
r = correlation coefficient of r
n = Number of respondents

Thus, the last step we take is to compare the t value with the t table value, using (df = N-2) and a significant level of 5%, then the rule of decision is if t count ≥ t table, then the item is valid. The results of the validity test for each item in the test questions can be seen in table 1.

Table 1. Results of the Test Question Validity Test

No. Item	r_{tabel}	r_{hitung}	Ket.
1	0,3291	0,54505	Valid
2	0,3291	0,78192	Valid
3	0,3291	0,64713	Valid
4	0,3291	0,77323	Valid
5	0,3291	0,63675	Valid

Based on the results of the calculation of the validity of the instrument, it was found that the instrument used was valid.

2. Reliability test

Reliability is an instrument that refers to the consistency of recording results (measurements) if the instrument is used by the same person or group of people at different times or if the instrument is used by different people or groups of people at different times. If the results are consistent, then the test instrument is reliable (reliable) or reliable (dependable). The technique used to find the reliability value of the test instruments in this study is to use the Alpha formula. Alpha formula is used to find the reliability value of test instruments whose scores are not 1 and 0, for example, a questionnaire or question in the form of a description. The process of calculating reliability in this study uses the alpha method. It as follows:

a. Calculating the variance of the score for each item $S_i^2 = \frac{\sum X_i^2 - \frac{(\sum X_i)^2}{N}}{N}$,

b. Sum the variance of all items $\sum S_i^2 = S_{i1}^2 + S_{i2}^2 + ...+ S_{in}^2$

Information: $\sum S_i^2$ = The sum of the variance of all items
$S_{i1}^2 + S_{i2}^2 + ...+ S_{in}^2$ = The variance of the 1st, 2nd item,

c. Calculating the total variance $S_t^2 = \frac{\sum X_t^2 - \frac{(\sum X_t)^2}{N}}{N}$

Information S_t^2 = Total variance
$\sum X_t^2$ = The sum of the squares X total
$(\sum X_t)^2$ = The total X is squared
N = Number of respondents.

d. Enter an Alpha value $r_{it} = (\frac{k}{k-1})(1- \frac{\sum S_t^2}{S_t^2})$.

Information r_{it} = value of reliability
$\sum S_i$ = Total variance in the score of each item
S_t =Total variance
K = Number of items.

The results of the reliability testing for each item in the test questions can be seen in table 2.

Table 2. Test Results Reliability Test Questions

Correlation coefficient	Interpretation
0,68872	High

Based on the results of the reliability test on the test questions, the coefficient obtained is that the test instrument has a high reliability interpretation.

3. Distinguishing Power Test

The distinguishing power of a question is the ability of a question to distinguish between students who have mastered the material and students who have not mastered the material. The distinguishing power of an item is said to be good if the item can distinguish the quality of the answer between students who already understand and students who do not understand. Following are the steps to test the distinguishing power (DP) in the form of description questions.

a. Calculating the total score of each student.
b. Sorting the total score from largest to smallest.
c. Determine the upper and lower groups.
d. Calculating the average score for each group, namely the upper group and the lower group.
e. Calculating the distinguishing power of the problem with the formula:

$DP = \frac{X_{KA}+X_{KB}}{SM}$

Information: DP = Discriminatory Power
X_{KA} = Upper group average
X_{KB} = Lower group average
SM = Maximum score The results of the distinguishing power test for each item in the test questions can be seen in table 3.

Table 3. Test Results of Differentiating Power of Test Items

Question Item Number	The amount of distinguishing power	Interpretation
1	0,25556	Enough
2	0,37778	Enough
3	0,305556	Enough
4	0,39963	Enough
5	0,205556	Enough

Based on the results of the different power of the test questions, the difference power test has been carried out in accordance with the predetermined formula and the criteria for the difference power test, of the 5 questions, it has sufficient difference power.

4. Difficulty Trial

The problem difficulty level is the opportunity to answer correctly a question at a certain ability level which is usually expressed by an index. The level of difficulty to find out whether the question is classified as difficult, moderate, or easy. Determining the level of difficulty on important questions, because knowing it can be a reference for researchers to choose questions with varying levels of difficulty. According to Suherman, it was stated that the questions that could be used were in the difficulty index from 0.20 to 0.80 [15]. Suherman that the items must be corrected if the difficulty intervals are 0.00-0.10 and 0.90-1.00 [15].

Here are the steps for calculating the difficulty level of the description questions:

a. Calculate the average for each item with the formula: Average = (Total score of each question) / (Number of students)
b. Calculate the level of difficulty with the formula: Difficulty level = (Average) / (Maximum score of each question)

c. Make an interpretation of the difficulty level of the problem by comparing the difficulty level.

Table 4. Test Results on the Level of Problem Test

Question Items	Trouble	Criteria
1	0,85	Easy
2	0,39	Moderate
3	0,70	Moderate
4	0,40	Moderate
5	0,71	Moderate

Based on the results of the difficulty level of the test questions, the difficulty level test has been carried out according to the predetermined formula and the criteria for the difficulty level of the questions, from the 5 questions, it is obtained 1 easy difficulty level and 4 questions having a moderate difficulty level.

Based on the description of the research subject's errors from the test results, the researcher conducted in-depth interviews with the research subjects. The purpose of conducting in-depth interviews is to find out students' mistakes and to know the factors that cause students to make these mistakes. The following is the percentage of student answers presented in graph form:

a. Find the equation for the circle with the center at O (0, 0) through the point (- 6, 2)!
b. Find the equation for the circle centered at P (4, 3) via point A (-5, 1)!
c. Determine the coordinates of the center and the radius of the circle if you know the circle equation $x^2 + y^2 - 2x - 6y– 15 = 0$.
d. A cruise ship positioned at coordinates (5.12) has a radar with a range of 45 km in all directions Determine: a. Write an equation modeling the maximum range of the ship's radar. b. Use the two-point distance formula to determine whether the radar can detect other ships at coordinates (50, 25).
e. Find the position of the line $2x - y = -4$ to the circle $x^2 + y^2 - 2x + 2y + 1 = 0$.

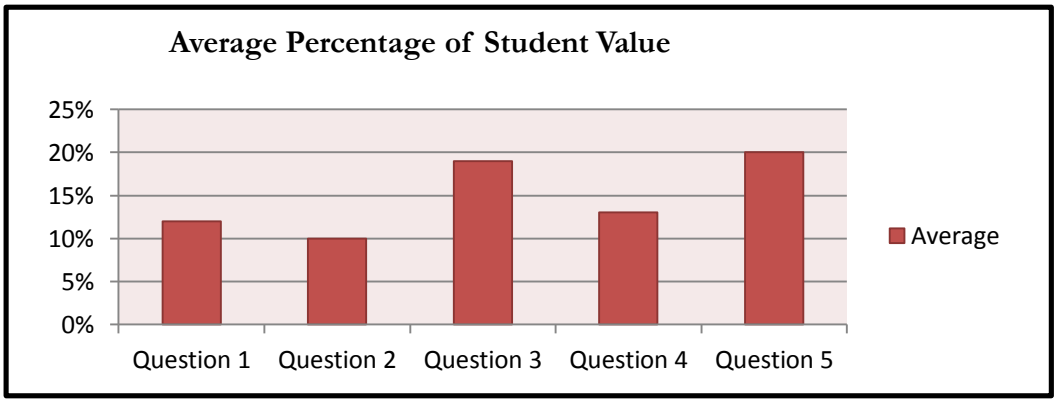

Figure 1. Graph of Average Students' Scores

Error analysis is used, namely according to the Big Indonesian Dictionary, error is a matter of error, error, negligence so that if the error is associated with the basic object of mathematics according to the error in question is fact error, concept error, principle error, error Operation. The following are clearer description of the form of errors made by students on the circle equation material [16].

a. Question 1

Find the equation for the circle with the center at O (0, 0) through the point (- 6, 2)!

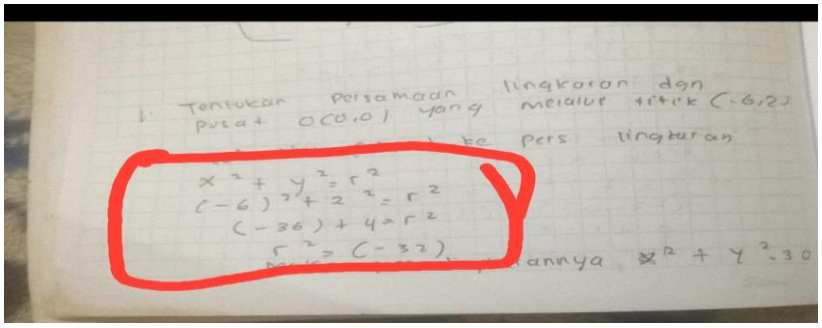

Figure 2. One of Student's Answer in Question 1

Figure 2 shows the mistakes made by students, namely concept errors, where the visible image of the students incorrectly uses the formula that is asked for the circle equation centered at O (0,0) but the student when solving the problem uses the formula for the circle equation centered on A (a, b). Operation error, where what the student drew was wrong in performing the count operation, the student did not know the negative power and multiplication, the student wrote negative 6 to the power of 2, the result was negative 36, so the calculation was wrong.

Table 5. Students' Errors in Question 1

Student Error	Number of Students	Percentage
False Fact	4	11
Concept Error	5	14
Principle Mistakes	-	-
Operation Error	9	25

From the table above, it was found that the mistakes made by students for question 1 were 4 fact errors, 5 concept errors, and 9 operating errors.

b. Question 2

Find the equation for the circle centered at P (4,3) via point A (-5,1)!

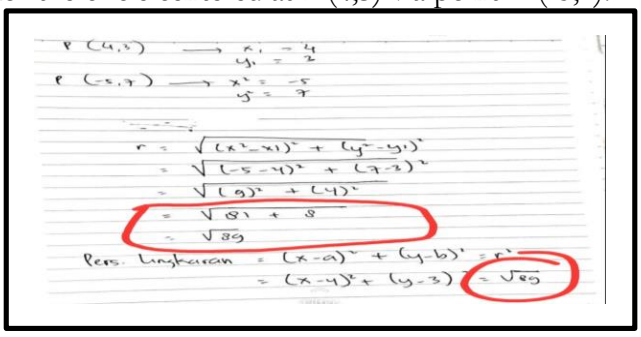

Figure 3. One of Student's Answer in Question 2

Figure 3 shows the mistakes made by students, namely concept errors, where it can be seen in the picture that students do not understand the questions correctly, what is being asked in the questions. What is asked from the question is the circle equation centered on A (a, b), the students should first look for the radius using the formula for the distance between two points, but students immediately look for the equation, factual errors, which can be seen in the student's picture. Unable to write down what is known in the problem, the student incorrectly determines the x and y values in the problem. It should be, the principal error, which is seen in the picture of the student in solving the problem, the student has studied the formulas and rules that apply in advance, but the student does not use these formulas and rules to answer questions, operation errors, which are shown in the picture of the student not correctly calculated in the question. It should be a value of r.

Table 6. Students' Errors in Question 2

Student Error	Number of Students	Percentage (%)
False Fact	10	28
Concept Error	5	14
Principle Mistakes	9	25
Operation Error	7	19

From the table above, it was found that the errors made by students for question 2 were fact errors of 10 people, misconceptions of 5 people, errors of principle 9 people, and operating errors of 7 people.

c. Question 3

Determine the coordinates of the center and the radius of the circle if you know the circle equation $x^2 + y^2 - 2x - 6y - 15 = 0$.

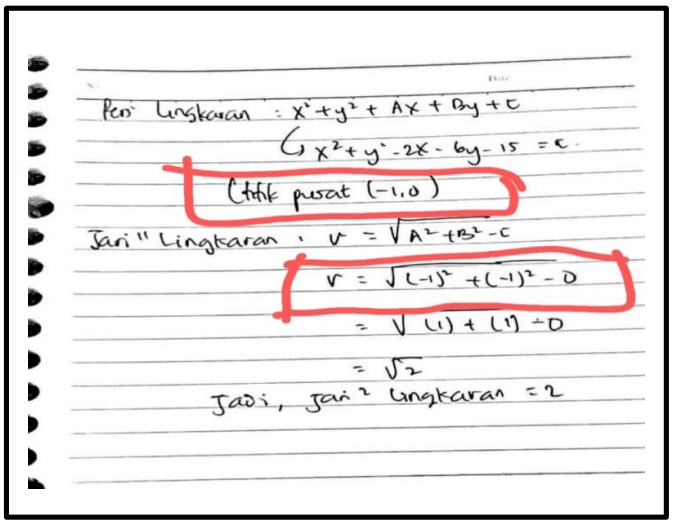

Figure 4. One of Student's Answer in Question 3

Figure 4 shows the mistakes made by students, namely, concept errors, which can be seen in the picture not understanding the questions correctly what is being asked in the questions. Students do not understand the concept of finding the center point of the circle and the radius of the circle if the equations are known, the fact that it is seen in the pictures of students in solving problems students cannot write the general equation of the circle itself so that students incorrectly determine the A, B and C values in circular equations, operating errors, where what is seen in the picture the students make mistakes in calculations. Students are not careful in adding and exponents, Principle errors, which can be seen in the students' pictures in solving these problems, students are still confused in using the formula to solve the problem.

Table 7. Students' Errors in Question 3

Student Error	Number of Students	Percentage (%)
False Fact	5	14
Concept Error	1	3
Principal Mistakes	3	8
Operation Error	6	17

From the table above, it was found that the mistakes made by students for question number 3 were 5 fact errors, 1 person misconception, 3 mistakes in principle, and 6 errors in operation.

d. Question 4

A cruise ship positioned at coordinates (5.12) has a radar with a range of 45 km in all directions Determine: a. Write an equation modeling the maximum range of the ship's radar. b. Use the two-point distance formula to determine whether the radar can detect other ships at coordinates (50, 25)

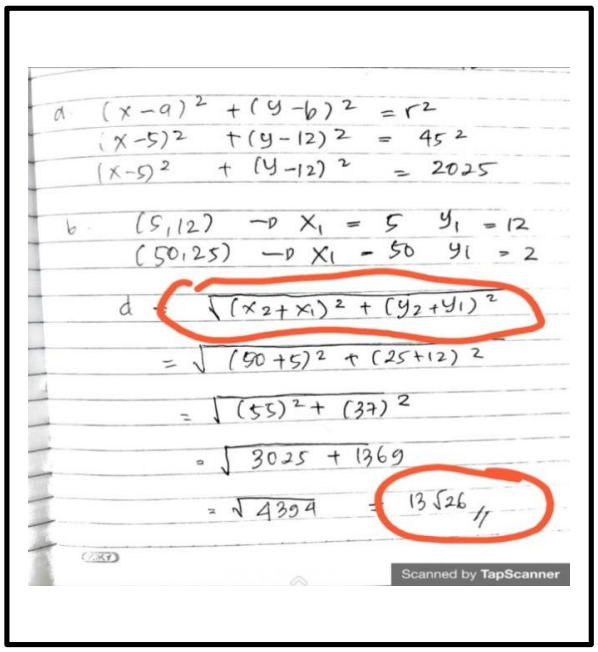

Figure 5. One of Student's Answer in Question 4

Figure 5 shows the mistakes made by students, namely fact errors, where what is seen in the pictures the students wrote incorrectly the distance formula should be $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$, concept errors, where students do not understand correctly what is asked in the questions in the form of story problems, the principle error, whereas seen from the picture the students are wrong in using the formula and the rules that apply should the students use the circle equation centered on A (a, b) but students use the formula for the circle equation centered at O (0, 0), the operating error, which is shown in the students' drawing is wrong in the summation. 45 + 13 should have been to the power of 2 first, but students just jumped in, making the result wrong.

Table 8. Students' Errors in Question 4

Student Error	Number of Students	Percentage (%)
False Fact	9	25
Concept Error	12	33
Principle Mistakes	10	28
Operation Error	6	17

From the table above, it was found that the mistakes made by students for question number 4 were 9 fact errors, 12 concept errors, 10 principles errors, and 6 operating errors.

e. Question 5

Find the position of the line 2x - y = -4 to the circle $x^2 + y^2 - 2x + 2y + 1 = 0$

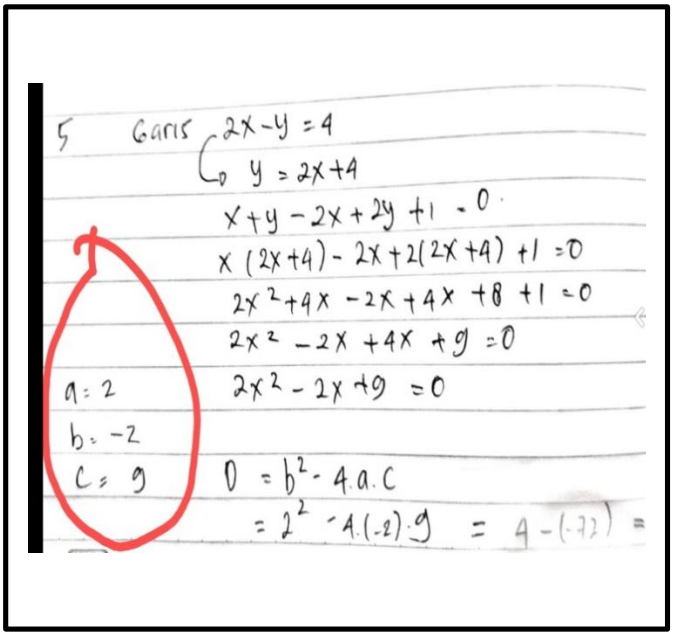

Figure 6. One of Student's Answer in Question 5

Figure 6 shows the mistakes made by students, namely, factual errors, which can be seen in the pictures that students incorrectly determine the values a, bm and c. The values of a = 5, b = 18, and c = 25 should be misconceptions, which can be seen in the picture that students do not understand finding the position of the line to the circle. Students consider that to find the position of the line against the circle only by using the discriminant value, they should look for the equation first and then determine the discriminatory value, operation error, which can be seen in the picture that the student is wrong in performing a calculation operation in solving the discriminant value, the discriminant value should be -176.

Table 9. Students' Errors in Question 5

Student Error	Number of Students	Percentage (%)
False Fact	11	30
Concept Error	8	22
Principal Mistakes	-	-
Operation Error	12	33

From the table above, it was found that the mistakes made by students for question number 4 were 11 fact errors, 8 concept errors, and 12 operating errors.

Table 10. Overall Mistakes That Students Make

Student Error	Number of Students	Percentage (%)
False Fact	39	27
Concept Error	31	22
Principle Mistakes	22	15
Operation Error	33	30

From the table above, the results obtained from the overall percentage of students in class XI Mulitimedia SMK Negeri 3 Pekanbaru who made mistakes in questions 1 to 1 in solving problems related to equations in fact errors were 39 0rang, 31 people misconceptions, 22 people error in principle, and errors operation of 33 people.

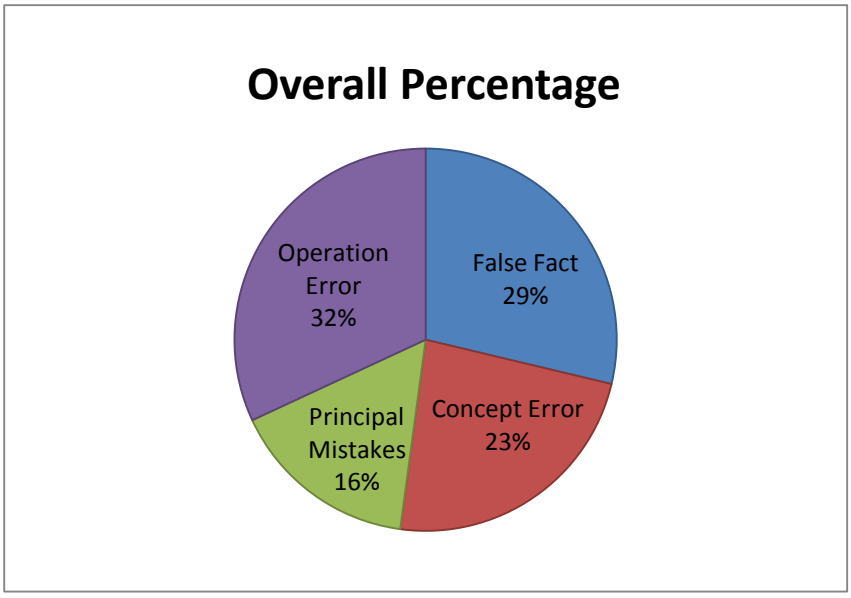

Figure 7. Pie Chart of Overall Mistakes That Students Make

The figure above is the total number of errors made by students on the circle equation problems obtained from students' mistakes in questions 1 to 5, which are already listed in the tables above. For more details, the researchers wrote down the results of student errors in the form in the diagram above.

CONCLUSIONS AND SUGGESTIONS

1. Students make fact mistakes as much as 29% due to the lack of accuracy of the students in writing the symbols of the circle equation so that the final result is wrong.
2. Students make 23% of misconceptions because students do not understand the questions well so that students are random in determining the formula used to solve the problem.
3. Students make principle errors as much as 16% because students are careless in determining the formula to solve the questions asked in determining the circle equation centered at O (0,0), but students instead use the formula for the circle equation centered on A (a, b).
4. Students make operation errors as much as 32% because students are not careful in doing algebraic operations and are in a hurry to work on these problems.

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